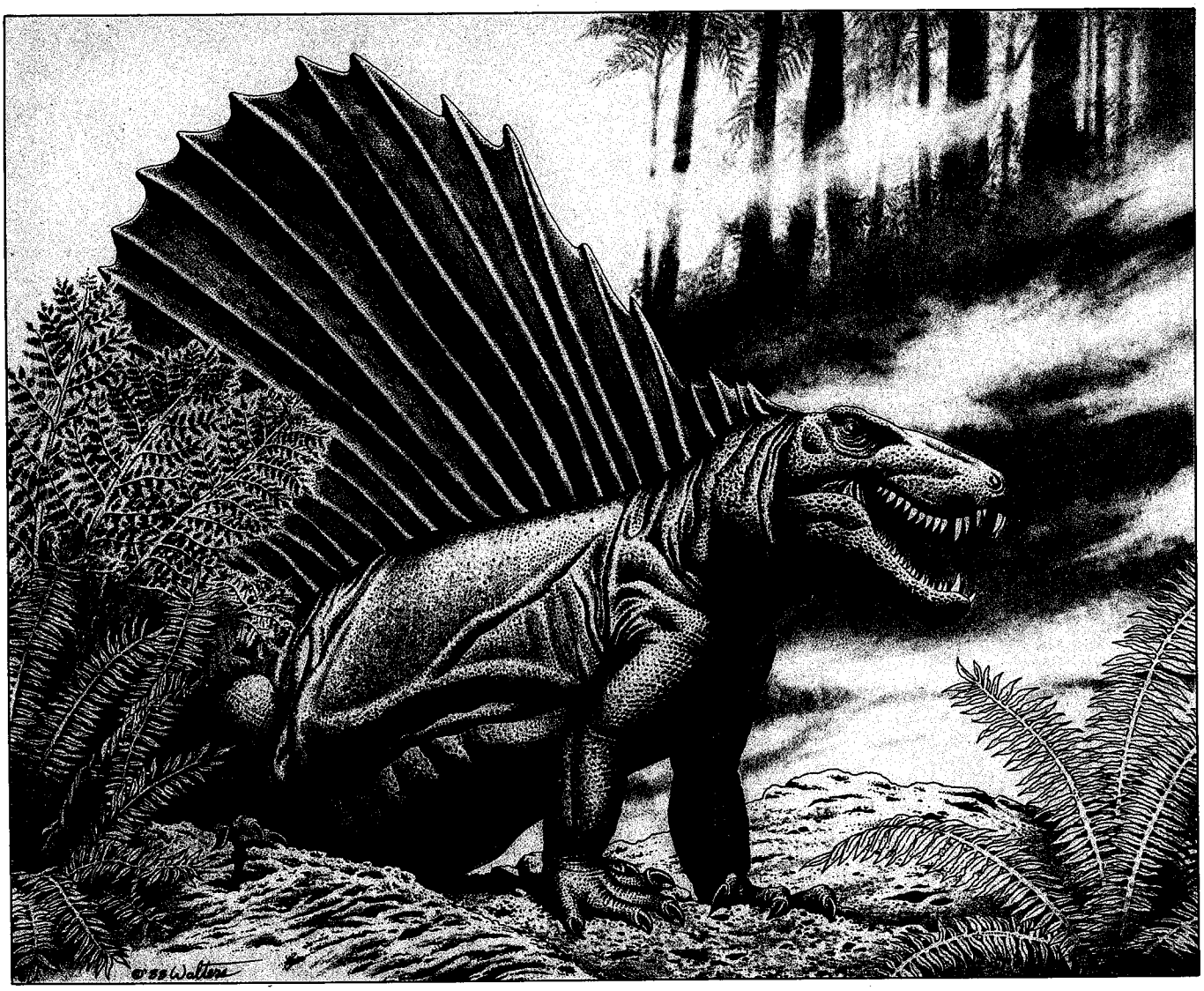
THE MOSASAUR



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The Biostratigraphy of the Lower Helderbergian Formations (Lower Devonian) as Exposed along Wallpack Ridge, Sussex County, New Jersey

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Abstract

The Lower Helderbergian formations (Lower Devonian) along Wallpack Ridge, Sussex County, New Jersey, have been reported by Epstein et al. (1967), Laporte (1969), and Barnett (1970) to be a time-transgressive limestone sequence as contrasted to the time-transgressive sequence of earlier authors. The Manlius Formation is of supratidal, intertidal, and subtidal environments of a shallow lagoon. The Coeymans Formation represents a reef or bar environment of the Kalkberg and New Scotland Formations. Faunal analyses of these formations indicate two supratidal, three intertidal, and one subtidal environment within the Manlius, and two biohermal and one nonbiohermal environment within the Coeymans. These environments are interpreted as minor periods of transgression and regression within a larger transgressive sequence.

Introduction

The area under investigation lies along the southeast and northeast slope and the top of Wallpack Ridge, Montague Township, Sussex County, New Jersey (U.S. Geological Survey Milford Pa.-N.J. 7.5' quadrangle; see Figure 1). The study area begins 425 feet north of the intersection of Myrtle Road and Ridge Road and extends 210 feet south along Ridge Road. Much of the area is covered with glacial till. Along the southeast slope (beginning at Ridge Road), a series of natural steps has been formed by erosion, exposing the underlying rock structure (Figure 2). The beds strike N53°E and dip 15° NW.

The Lower Helderbergian Group includes the Manlius, Coeymans, Kalkberg, and New Scotland Formations. They have been described by many authors prior to 1962 as being a time-transgressive stratigraphic limestone and shale sequence, each formation having been deposited simultaneously across the entire basin. Rickard (1962) concluded that these formations in New York were deposited by a transgressive sea in a subsiding basin and represent a time-transgressive sequence. Each formation thus represents a major depositional environment in a shallow basin which was deepening to the east.

Examination of these formations indicates that this time-transgressive sequence also exists in northwestern New Jersey. Rickard (1962) and Laporte (1969), working in New York, and Epstein et al. (1967) and Barnett (1970), working in New Jersey, have established the extent of the major environments represented by these formations (Figures 3, 4).

Laporte (1969) does not elaborate on the minor transgressions and regressions of the New York Helderberg Sea. Biostratigraphic analysis by the present author indicates fluctuations of the Helderberg Sea and records minor changes of the environment within the Lower Helderbergian formations in New Jersey (Figure 7).

Stratigraphy

Comparing the lithologic and paleontologic data compiled at the study site, each formation was identified using descriptions by Epstein et al. (1967) and Barnett (1970). Interpretation of the environments which existed at the time of deposition was based on the examination of the collected data in conjunction with information retrieved from the reports of Swartz & Whitmore (1956), Rickard (1962), Epstein et al. (1967), Laporte

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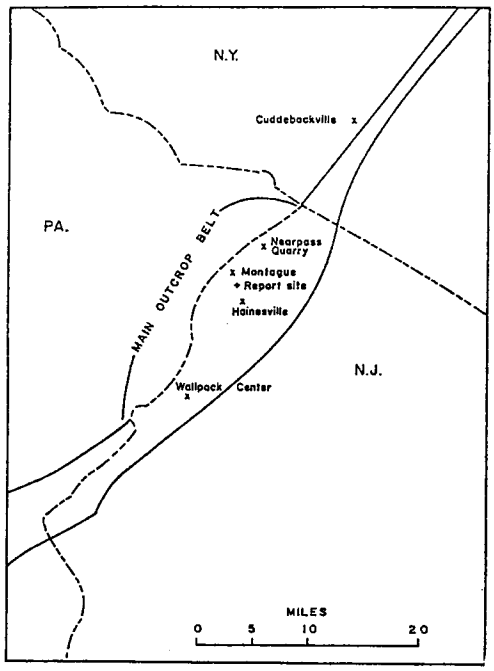


Figure 1. Outcrop of Silurian and Devonian rocks with the location of the study site.

(1967), Barnett (1970), Blatt (1972), and Valentine (1973) (Figures 5, 6).

Manlius Formation

The New York members of the Manlius Formation in ascending order are: Thacher Limestone, Olney Limestone, Elmwood Waterlime, Clark Reservation Limestone, and the Jamesville Limestone (Rickard, 1962, p. 42). Only the Thacher Member is

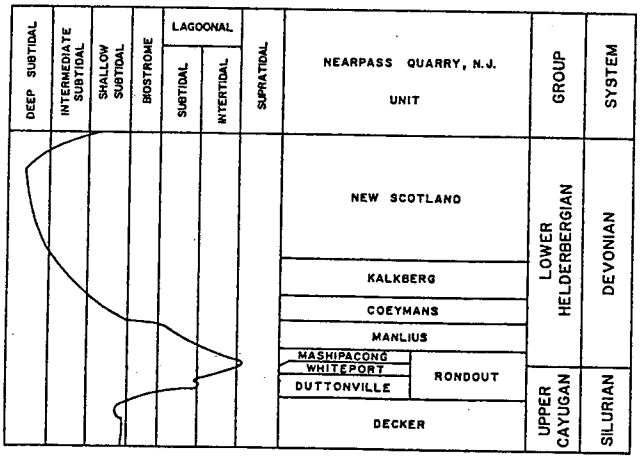


Figure 3. Environment changes during late Cayugan and early Helderbergian time at Nearpass Quarry along Wallpack Ridge, New Jersey. (Modified from Barnett, 1970.)

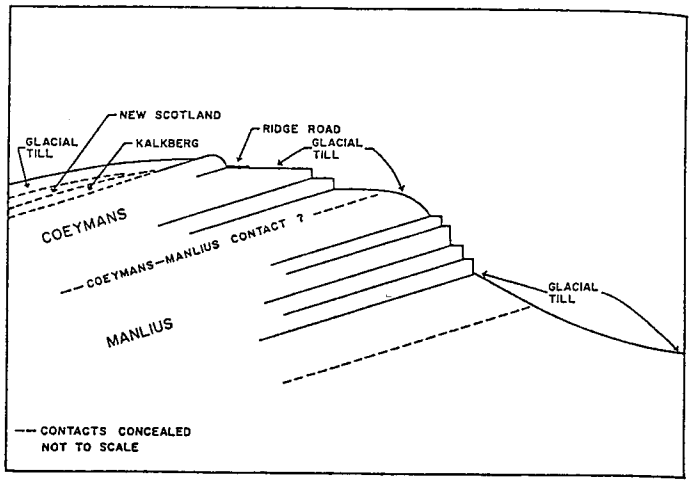


Figure 2. Generalized cross-section of the study site showing relationships of formations.

recognized in the northwestern New Jersey-southeastern New York-northeastern Pennsylvania area (Figure 6).

The upper contact with the Coeymans Formation and the lower contact with the Rondout Formation are concealed by glacial till. A total of 10.42 feet is accessible and consists of a medium-dark gray, fine- to coarse-grained limestone, weathering to a light gray. The beds vary from under one inch to 18 inches in thickness. Several of the thinly-bedded zones have silty interbeds. Tentaculitids, ostracodes, and brachiopods are abundant, with several beds of blue-green algal mats and algal stromatolites. Most of the tentaculitids and ostracodes are intact; many of the brachiopods are fragmented (Figure 7).

The fauna identified from the Manlius Formation at the study site is:

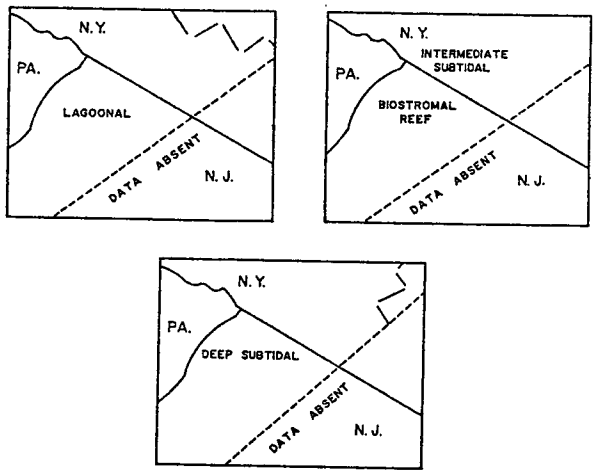


Figure 4. The paleoenvironments of the time of deposition of: (A) the upper part of the Thacher Member of the Manlius Formation, (B) the middle part of the Ravena Member of the Coeymans Formation, (C) the middle part of the New Scotland Formation at Nearpass Quarry. (Modified from Barnett, 1970.)

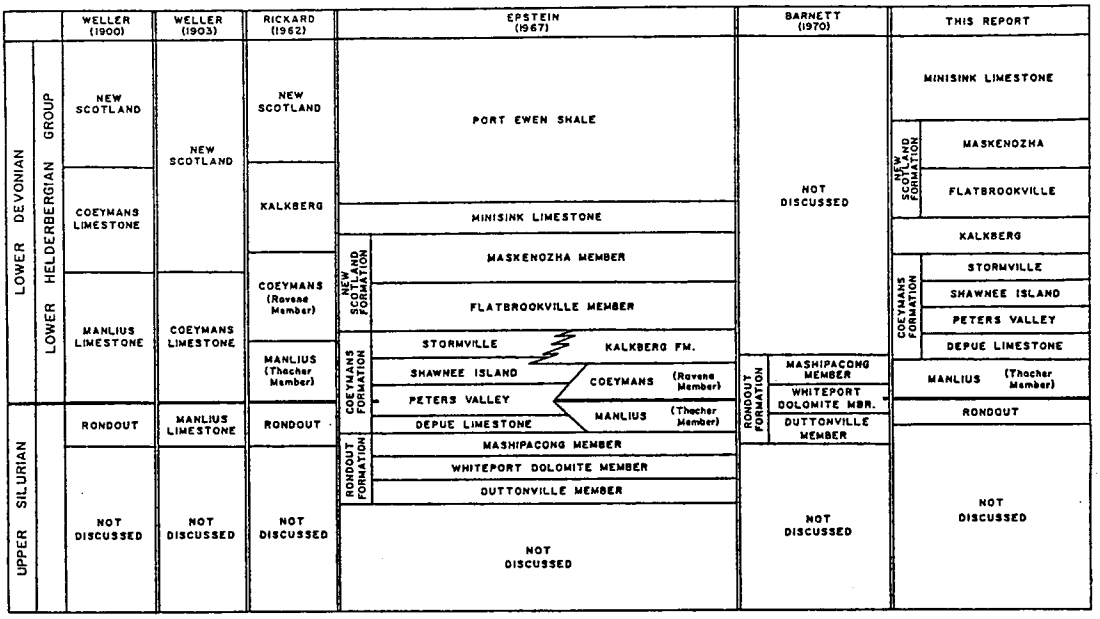


Figure 5. The proposed Silurian-Devonian boundary and nomenclature for New Jersey. Actual thicknesses are not implied.

Algae
Stromatolites (SS type of Logan et al.,1962)
Blue-green algal mats

Corals
Rugose coral (unidentified)

Bryozoans
Monotrypella(?) *arbusculum* Hall & Simpson

Brachiopods
"Camarotoechia" semiplicata (Conrad)
Mesodouvillina (*Mesodouvillina*) *varistriata* (Conrad)
Howellella vanuxemi (Hall)
Centronella biplicata Weller

Pelecypods
Magambonia aviculoidea Hall

Cricoconarids
Tentaculites gyracanthus (Eaton)

Ostracodes
Herrmannina alta (Conrad)

Coeymans Formation

Epstein et al. (1967) redefined the Coeymans Formation in New Jersey and recognized five members. In ascending order they are: Ravena Limestone, Depue Limestone, Peters Valley, Shawnee Island, and Stormville (Figure 5).

Only the Shawnee Island Member is exposed at the report site, where approximately five feet of it are accessible. The lower contact with the Thatcher Member of the Manlius Formation and the upper contact with the Kalkberg Formation are covered with glacial till. Ridge Road has been graded across the uppermost portion of the member, thereby limiting its exposure.

Two biohermal facies are recognized, separated by a non-biohermal facies. The lower biohermal sequence on the southeast ridge slope is a medium-gray, coarse-grained, non-bedded bioclastic limestone with three massive zones of the tabulate coral *Favosites helderbergiae* Hall. This limestone also contains numerous unidentifiably fragmented brachiopods and crinoid columnals. The most common fossil within this unit, the brachiopod *Gypidula coeymanensis* Schuchert, occurs throughout the entire vertical extent of the formation.

Descending the northeast slope along Myrtle Road, the more prevalent nonbiohermal facies occurs. Its total thickness is unknown, approximately five inches being exposed. It consists of a medium-grained argillaceous limestone containing crinoid columnals, *Gypidula coeymanensis* and other brachiopod fragments, and changes rapidly into the overlying biohermal facies.

The second biohermal sequence is similar in lithologic character to the first, but has a greater abundance of identifiable fossils. The upper portion is covered with glacial till and has been eroded by glacial activity (Figure 7).

The fauna identified from the Coeymans Formation at the study site is:

Corals
Favosites helderbergiae Hall

Brachiopods
Gypidula coeymanensis Schuchert
Leptaena "rhomboidalis" (Wilckens)
Meristella laevis (Vanuxem)
Megakozlowskiellina perlamellosa (Hall)
Costistrophonella punctulifera (Conrad)

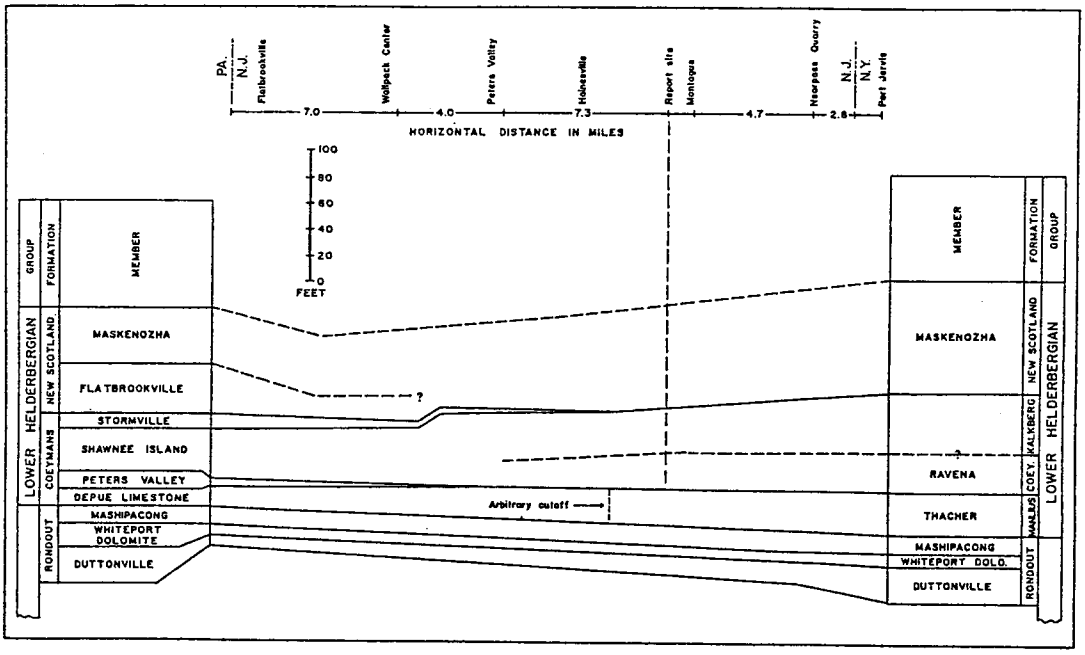


Figure 6. The relationship between the Lower Helderbergian formations in southeastern New York and northwestern New Jersey. (Modified from Epstein et al., 1967.)

Epstein et al. (1967) also recorded rugose corals, trepostomate bryozoans, and crinoid columnals as being common in the general area.

Kalkberg Formation

The Kalkberg Formation consists of a medium-dark gray, medium-grained, argillaceous limestone. The exposure at this site is limited; its total thickness and the contacts with the underlying Coeymans Formation and the overlying New Scotland Formation are not exposed at this locale (Figure 7).

The fauna identified from the Kalkberg Formation at the study site is:

Corals
- *Enterolasma strictum* (Hall)

Bryozoans
- *Paleschara incrustans* Hall
- Bryozoan undetermined

Brachiopods
- *Parazyga deweyi* (Hall)
- *Leptaena "rhomboidalis"* (Wilckens)
- *Discomyorthis oblata* (Hall)
- *Levenea subcarinata* (Hall)
- *Isorthis perelegans* (Hall)
- *Uncinulus pyramidatus* (Hall)
- *Eatonia medialis* (Vanuxem)
- *Costistrophonella punctulifera* (Conrad)

Crinoids
- Crinoid columnals

New Scotland Formation

Only the Meskenozha Member, a dark gray shale of undetermined total thickness, is exposed at this site. The lower contact with the Kalkberg Formation and the upper contact with the Port Ewen Formation are not exposed at this locale (Figure 7).

The fauna identified from the New Scotland Formation at the study site is:

Bryozoans
- Bryozoans undetermined

Brachiopods
- *Macropleura macropleura* (Conrad)
- *Meristela laevis* (Vanuxem)
- *Discomyorthis oblata* (Hall)
- *Leptaena "rhomboidalis"* (Wilckens)

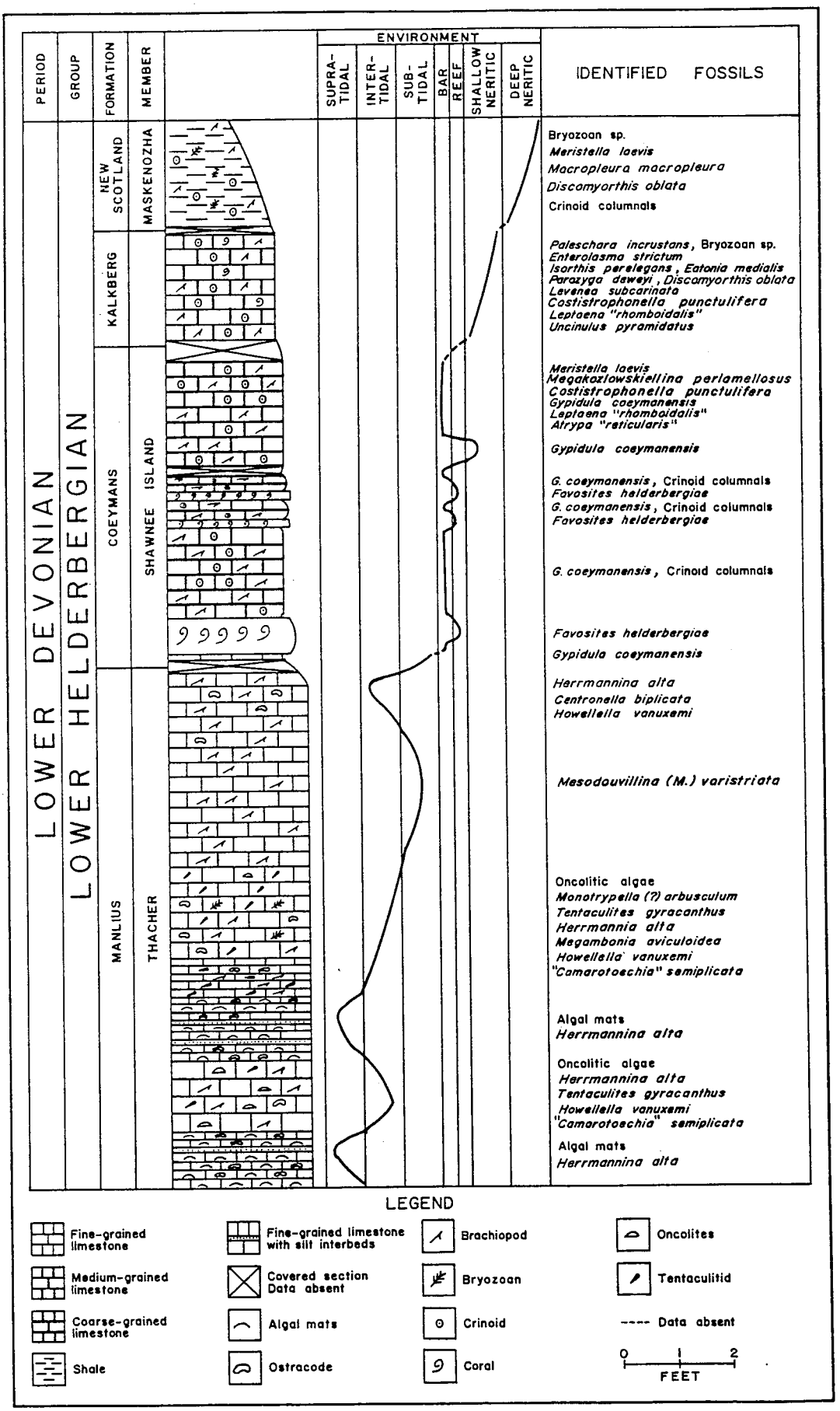
Crinoids
- Crinoid stems and columnals

Discussion of Depositional Environments

Interpretation of the data collected at the study site indicates that there have been three minor periods of transgression within the studied portion of the Thatcher Member of the Manlius Formation (Figure 7). The environment of deposition was altered as the sea transgressed and regressed. Beginning with a supratidal environment, at the lowest portion of the exposure, it continues through an intertidal, supratidal, intertidal, subtidal, and intertidal sequence.

The supratidal environment is characterized by algal mats and the ostracode *Herrmannina alta* (Conrad) (Valentine, 1973),

(Facing page.) **Figure 7.** The biostratigraphy of a section of Wallpack Ridge, Sussex County, New Jersey.


PERIOD
GROUP
FORMATION
MEMBER
ENVIRONMENT
SUPRA-TIDAL
INTER-TIDAL
SUB-TIDAL
BAR
REEF
SHALLOW NERITIC
DEEP NERITIC
IDENTIFIED FOSSILS
LOWER DEVONIAN
LOWER HELDERBERGIAN
NEW SCOTLAND
MASKENOZHA
KALKBERG
COEYMANS
SHAWNEE ISLAND
MANLIUS
THACHER
Bryozoan sp.
Meristella laevis
Macropleura macropleura
Discomyorthis oblata
Crinoid columnals
Paleschara incrustans, Bryozoan sp.
Enterolasma strictum
Isorthis perelegans, Eatonia medialis
Parazyga daweyi, Discomyorthis oblata
Levenea subcarinata
Costistrophonella punctulifera
Leptaena "rhomboidalis"
Uncinulus pyramidatus
Meristella laevis
Megakozlowskiellina perlamellosus
Costistrophonella punctulifera
Gypidula coeymanensis
Leptaena "rhomboidalis"
Atrypa "reticularis"
Gypidula coeymanensis
G. coeymanensis, Crinoid columnals
Favosites helderbergiae
G. coeymanensis, Crinoid columnals
Favosites helderbergiae
G. coeymanensis, Crinoid columnals
Favosites helderbergiae
Gypidula coeymanensis
Herrmannina alta
Centronella biplicata
Howellella vanuxemi
Mesodouvillina (M.) varistriata
Oncolitic algae
Monotrypella (?) arbusculum
Tentaculites gyracanthus
Herrmannia alta
Megambonia aviculoidea
Howellella vanuxemi
"Camarotoechia" semiplicata
Algal mats
Herrmannina alta
Oncolitic algae
Herrmannina alta
Tentaculites gyracanthus
Howellella vanuxemi
"Camarotoechia" semiplicata
Algal mats
Herrmannina alta
LEGEND
Fine-grained limestone
Medium-grained limestone
Coarse-grained limestone
Shale
Fine-grained limestone with silt interbeds
Covered section Data absent
Algal mats
Ostracode
Brachiopod
Bryozoan
Crinoid
Coral
Oncolites
Tentaculitid
Data absent
0 1 2
FEET

contained within a thinly bedded limestone with silt interbeds. Exposure to windblown sand or land-derived erosional material is indicated by these silt interbeds. Periodic submergence, due to higher-than-normal tides or storms, allowed the deposition of carbonate material, presumably washed ashore, with the resulting sequence of algal mats.

The intertidal environment is characterized by *Herrmanina alta* (Conrad), *Tentaculites gyracanthus* (Eaton), *Howellella vanuxemi* (Hall), the trepostomate bryozoan *Monotrypella*(?) *arbusculum* Hall & Simpson, and oncolitic algae (Valentine, 1973). The first three species named occur in great abundance. Other fossils identified within the intertidal environment are *"Camarotoechia" semiplicata* (Conrad), *Centronella biplicata* Weller, *Megambnia aviculoidea* Hall, and an abundance of brachiopod fragments. The texture of the limestone is fine- to medium-grained and the beds vary in thickness from one inch to 16 inches.

The abundance of the paleoenvironmentally diagnostic brachiopod *Mesodouvillina* (*Mesodouvillina*) *varistriata* (Conrad), contained within a very fine-grained limestone, is characteristic of the subtidal environment of the Manlius Formation. The absence of a varied fauna suggests a somewhat ecologically restricted environment.

The depositional sequence of the Manlius Formation may be related to the normal history of a carbonate platform, interrupted by a transgressing sea and a subsiding basin. Sedimentation on a carbonate platform within the intertidal and supratidal zones results in the shallowing of water and a seaward extension of the shoreline. This type of regressive accumulation will proceed until almost the entire platform is exposed above sea level, resulting in sediments deposited in a supratidal environment overlying sediments of an intertidal environment (Blatt et al., 1972). Providing that sea level remains constant, erosion will begin on the exposed sediments. However, this process was interrupted during Manlius time when the sea transgressed or the basin subsided: sediments of intertidal and subtidal environments accumulated on top of supratidal and intertidal sediments.

Leperditiid ostracodes flourish chiefly in an environment not favorable to the majority of bottom-dwellers, inhabiting waters of appreciably lowered or heightened salinities (Swartz & Whitmore, 1956). The abundance of ostracodes, their excellent state of preservation, and the scarcity of bottom-dwelling species also indicate a rather restricted environment.

The Manlius Formation represents a series of marine environments of normal carbonate deposition, a transgressive sea, and a subsiding basin, causing regression of the sea within a shallow, somewhat restricted, lagoon.

The lower biohermal facies of the Shawnee Island Member of the Coeymans Formation is a reef and bar deposit in a shallow neritic environment. The three zones of the coral *Favosites helderbergiae* Hall represent the migration of the edges of a reef as the result of the transgression of the sea. The bioclastic sediments between the coral zones are interpreted as being the result of the regression of the sea, which caused a lowering of the wave base and destruction of a portion of the reef. This increased water agitation, resulting in the deposition of coarse, bioclastic materials on the landward side of the reef (in the form of shell fragments, crinoid columnals, and reworked sediments), resulting in poor preservation of the fossils. The wide bands of biogenic limestone are interpreted as bank deposits and clastic deposition in an area of an offshore bar (Epstein et al., 1967).

The second biohermal facies has a better-preserved fauna indicating a slightly higher wave base and less water agitation. The fossils collected from this facies include *Leptaena "rhomboidalis"* (Wilckens), *Gypidula coeymanensis* Schuchert, *Atrypa "reticularis"* (Linne), *Megakozlowskielina perlamellosa* (Hall), *Costistrophonella punctulifera* (Conrad), *Meristella laevis* (Vanuxem), and crinoid columnals.

The nonbiohermal facies is lithologically different from the biohermal facies. It consists of a medium-grained crystalline limestone which indicates deposition in a less-agitated environment with a higher wave base than the biohermal facies.

The Coeymans Formation represents environments with deeper and more agitated waters than the Manlius. Transgressive and regressive sequences are represented respectively by the interfingering of coral and bioclastic sediments (biohermal facies) and a less-agitated, deeper-water biohermal facies (Figure 7).

The Kalkberg and New Scotland Formations record a continuously deepening sequence (Figure 7). The depositional environment of the Kalkberg was that of a shallow neritic shelf. The abundance and variety of brachiopods, with corals, bryozoans, and crinoid columnals, contained within a medium-grained limestone, are indicators of this environment. Laporte (1969) and Barnett (1970) interpreted this environment as a basinal sublittoral environment with the depositional interface below wave base.

The New Scotland Formation records a depositional environment which was deeper, with less water agitation, than the Kalkberg. Deposition occurred on a broad open shelf, below wave base, with a greater influx of terrigenous detritus than the Kalkberg (Laporte, 1969).

Conclusion

Minor periods of transgression and regression are recorded within the major transgressive sequence of the Lower Helderbergian rocks of northwestern New Jersey. As exposed at the study site, the Manlius Formation records three regressive and two transgressive periods. This is shown by the supratidal-intertidal-supratidal-intertidal-subtidal-intertidal sequence in the paleoenvironment. The Coeymans Formation records a major period of transgression, within which occur four minor transgressive and four minor regressive episodes, as indicated by the interfingering of coral and coarse bioclastic sediments and the occurrence of a medium-grained limestone. The abundance and variety of fossils within the medium-grained limestone of the Kalkberg Formation and the change in rock type to the shale of the New Scotland Formation (Figure 7) reflect the major continuing transgressive sequence.

Further work is recommended along Wallpack Ridge in New Jersey, and in adjacent portions of southeastern New York and northeastern Pennsylvania, to obtain more extensive data and to extend the area of study of the depositional sequence of the Lower Helderbergian formations.

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